일반논문 (Regular Paper)
방송공학회논문지 제22권 제1호, 2017년 1월 (JBE Vol. 22, No. 1, January 2017)
https://doi.org/10.5909/JBE.2017.22.1.78
ISSN 2287-9137 (Online) ISSN 1226-7953 (Print)

사물인터넷을 이용한 시각 장애자 보조 방법

네바디타 사후[a)], 정 민 혁[a)], 전 종 훈[a)], 김 상 균[a)‡]

A Vision Disabled-Aid using the Context of Internet of Things

Nevadita Sahu[a)], Min Hyuk Jeong[a)], Jonghoon Chun[a)], and Sang-Kyun Kim[a)‡]

요 약

사물인터넷은 장애인들의 삶의 질을 높이기 좋은 도구로 활용될 수 있다. 특히 시각 장애인의 경우 목적지를 찾고, 진행 경로의 장애물을 발견하여 회피하거나, 목적지로의 진행 방향을 교정하는 등의 도움이 필요하다. 이러한 필요성을 바탕으로, 본 논문에서는 사물인터넷을 이용한 기초적인 장애물 회피 및 내비게이션 시스템을 제안한다. 제안된 시스템은 RFID 리더와 초음파 센서를 탑재한 스마트 지팡이, 스마트폰, 그리고 인터넷을 포함한다. 장애물 회피를 위해 초음파 센서로부터 취득된 데이터는 국제표준데이터 포맷(ISO/IEC 23005-5)으로 변환되어 스마트폰에 전달된다. 진행경로에 설치된 RFID 태그를 이용해 시각 장애인의 위치를 파악하고, 보이스 메시지를 통해 이동 경로에 대한 정보를 알려주며, 장애물을 피하기 위한 경보를 사용자에게 전해 준다. 제안된 시스템은 대학 캠퍼스 내에서 성공적으로 테스트 검증되었다.

Abstract

The Internet of Things can offer disabled people the assistance and support, which is essential to achieve a good quality of life. The visually impaired people need assistance in finding locations, detecting obstacles on the way, and getting directions while moving around to reach their destination. Based on this persistent need, this paper proposes a navigation system for blind people using Internet of Things. The technologies used in our proposed system are: a smart cane containing an RFID reader and an ultrasonic sensor, a smart phone and Internet. The sensed data from the ultrasonic sensor for detecting obstacle is converted to International Standard format from ISO/IEC 23005-5 (MPEG-V Part 5). The system detects the blind person's location using the RFID tags implemented on the way. The system uses voice message in the smart phone to communicate with the blind person to lead him to his destination. The proposed system has been tested to navigate successfully in the campus.

Keywords : Internet of things, MPEG-V, Visually impaired people, Navigation system, RFID

---

a) 명지대학교 컴퓨터공학과(Myongji University Computer Engineering Department)
‡ Corresponding Author : 김상균(Sang-Kyun Kim)
E-mail: goldmunt@gmail.com
Tel: +82-31-330-6443
ORCID: http://orcid.org/0000-0002-2359-8709
※ This work was supported by the ICT R&D program of MSIP/IITP. [B0126-15-1013, Development of generation and consumption of Jigsaw-liked Ultra-Wide Viewing Spacial Media].
· Manuscript received October 7, 2016; Revised November 15, 2016; Accepted November 15, 2016.

I. Introduction

The Internet of Things (IoT) is the most effective technological revolution connecting the real world and computing technology. The IoT can be implemented in many directions. It basically describes a world of networked devices, which are interconnected and derive some meaningful information through Internet. In IoT, different small embedded devices such as sensors and actuators are the cornerstone of the future Internet transformation. These devices collect the physical world information and deliver it into the virtual world, where it can be used in many applications in order to serve the world. In order to make use of these data generated by all the resource-constrained devices, all these need to be integrated into the Internet, so that “Things-to-Things” communication can be established.

IoT enables a new way of communication between people and things and in between things themselves. In this paper we proposed a navigation system implementing Internet of things to help the visually impaired people. As the number of visually impaired individuals is increasing along with low-vision or night blindness, the technology is failing to support them. One of the main obstacles in daily life of a visually impaired person is to safely navigate from one place to other without any assistance, particularly in an unacquainted place. Now-a-days all smart phones provide different applications with GPS access for navigation. Along with that the Radio Frequency Identifiers (RFID) technology can be applied to make the system more reliable.

There are several studies focusing on the assistance of the visually impaired people, especially for navigating in an unknown area. The main issues are the freedom of movement and independency. For this reason, the Radio Frequency Identifiers (RFID) technology can be applied to make the system more reliable.

A mobile application was developed by [1], which helps the visually impaired to navigate by only using the smart phone avoiding carrying other devices. In addition, a mobile blind navigation system using RFID was proposed by [2]. The system only navigates the blind user as per the GPS and RFID tags. It does not alert the user in case of any obstacles ahead. Similar kind of system is also proposed in [3] implementing an RFID reader and other hardware modules into a blind person’s stick. An implementation of the Constrained Application Protocol (CoAP) over 6LoWPAN for providing IoT services in the BLE networks is proposed in [4].

Navigation systems are targeted at addressing one or more typical navigation problems encountered by the visually impaired. Our System proposes a smart cane which contains the RFID reader antenna, which helps the visually impaired individual to be aware of his location, by getting the RFID tag information installed on the path ways. Also we have implemented an ultrasonic sensor in the cane to detect any obstacles ahead in order to make the user’s navigation safe. Smart phones are being used widely among the visually impaired individuals. In our system, a smart phone or a PDA can be the main monitoring station, which receives the instruction from the server, which is connected through Internet and thus helps the user to navigate comfortably to his/her destination.

The fast growth of IoT technology drives the connection of various smart objects through internet, which leads to the generation of huge heterogenous data. The reason behind the heterogeneity problem of the data formats in IoT system is the diversity of “Things” connected. So, providing a standard way to represent these sensor data will be really helpful. The MPEG international standardization group provides a standard known as MPEG-V(ISO/IEC 23005) [8][[9]. The MPEG-V standard’s goal is to define a standard data exchange format between the sensors and the actuators, which can overcome the data heterogeneity hurdle in most of the IoT systems. MPEG-V Part 5 [8] defines the standard XML schema for describing Sensed Information (SI) and Device Commands. This Part provides data formats for interaction devices such as sensors and actuators. We have implemented our IoT system based on the MPEG-V standard.

This paper has the designated structure as follows. In section II we discuss the general IoT system architecture Layers. Section III describes the proposed IoT navigation system design and section IV describes the technical implementation. In section V, we have shown our experiments and results. And finally in Section VI, the future work is outlined and the paper is concluded.

II. IoT System Architecture

The general IoT architecture from technical point of view is shown in figure 1. Any IoT system is categorized into three basic layers. The basic layers and its components and functionalities are described below:

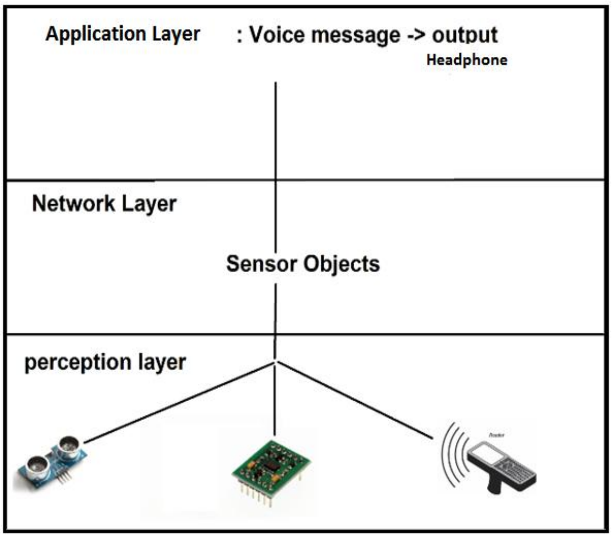

그림 1. IoT 시스템 아키텍쳐
Fig. 1. IoT system architecture

1. Perception Layer

Perception layer is the base layer for any IoT system. It consists of sensor devices and physical objects. The sensors can be RFID, Infrared sensor, ultrasonic sensor, or 2D-bacode. This layer provides context-aware information of the user through the sensors attached to the user. In case of our system, the RFID reader, RFID tags, and the ultrasonic sensor are the components of this layer. The smart cane contains a RFID tag reader with an antenna, which emits the radio waves. The RFID tags installed on the way respond by sending back their stored data, which helps in identifying the blind person's location. Each RFID tag has a unique ID. This data is sent from the perception layer to the server through the network layer. Its main task is to identify objects and gather the information.

2. Network Layer

The Network layer is also called as Transmission Layer. It is the middle layer which helps in transmitting the sensor data from the perception layer to the application layer. It can consists of a converged networks, may be wireless or wired. The transmission technologies depend on the sensor devices and it can be 3G, Bluetooth, Wifi, ZigBee etc. It is necessary to ensure the connectivity, interoperability and compatibility of heterogeneous networks. This layer transfers the sensor data from sensor devices to the information processing system.

3. Application Layer

The Application layer provides a global management of the applications based on the processed information. Actuators belong to this layer. In application layer the services are run by the servers, which provide the interface for communication. In our case the RFID application server is useful in navigating the blind person. It gets the tag information along with current location and the destination. The route can be computed and played as voice message through the headphone to help the user.

III. Proposed IoT Navigation System

The proposed IoT navigation system use case scenario for blind people is shown in figure 2. The system consists of different sensors and actuators connected over Internet to help the blind person navigate easily in an unknown area. As shown in the figure 2, the RFID tags are installed all along the way. The blind person carries a cane which contains an RFID reader which reads the nearby RFID tag identification number. Through this tag ID we can get the blind person's current location. Also in order to keep the blind user safe from any obstacles coming on the way, we have implemented an ultrasonic sensor. This provides the information if any obstacle appears while the blind user is walking on the way. While the blind user walks on the way, it is very important to keep track of the direction of his motion in order to avoid any side falls or accident. For this purpose we are using the compass to keep track of the user's motion direction and angle.

The blind user can provide the destination location as an input voice message through the smart phone. In our system we use smart phone as the monitoring system which communicates with the blind user. All the sensor data are transmitted to the server through Internet. From the server the route messages and the alert messages are played as voice message in the smart phone of the blind user in order to help them navigate safely to their destination. We used the Google voice API for text to speech conversion and speech to text conversion.

The data flow of the system and "Thing-to-Things" connection diagram is shown in figure 3. The location information of each RFID tag data and the next RFID tag's location information is stored in the database. The ultrasonic sensor sends the distance of any object ahead. The direction guider retrieves the data from the database and plays it as voice message in the user's smart phone.

The different connected "Things" of the system are described below:

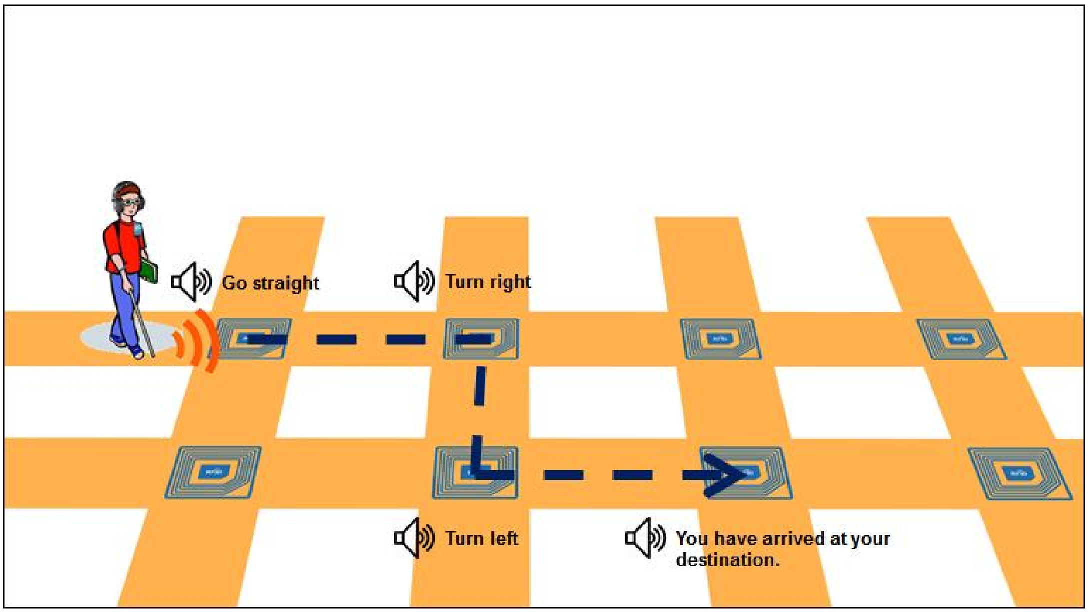

그림 2. 시각 장애인 용 IoT 내비게이션 시스템 사용자 시나리오
Fig. 2. IoT navigation system use case scenario for a visually impaired person

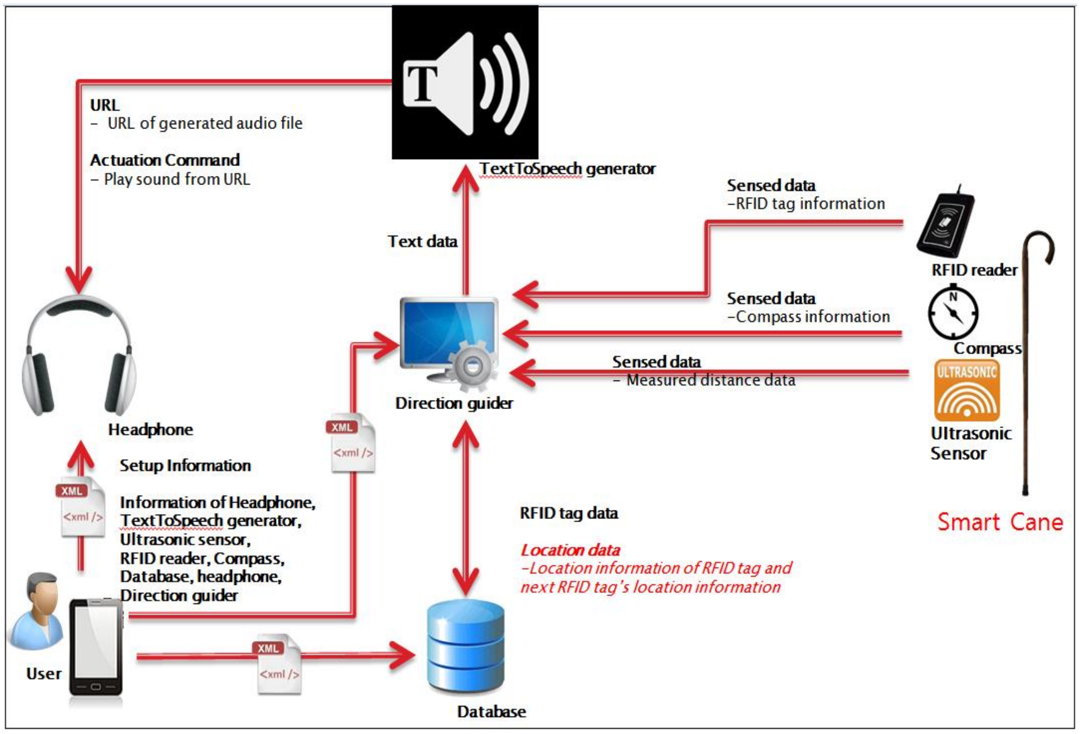

그림 3. 시각 장애인 용 IoT 내비게이션 시스템 데이터 흐름도
Fig. 3. IoT navigation system data flow diagram for a visually impaired person

1. RFID tag: the RFID tag can transmit data to a reader by using radio waves. In our implementation RFID tags (125 kHz) are used. We have installed the RFID tags in the campus.
2. RFID reader: It can read data from the companionable RFID tags. The main components of the RFID reader are: transmitter, receiver, microprocessor, memory, input/output channel for external sensor, controller, communication interface, power [5]. For our implementation RFID reader ID20LA is used. It has a built-in antenna with read range of 15+ cm. The RFID reader is installed in the smart cane.
3. Ultrasonic sensor: an ultrasonic sensor detects the distance of any objects ahead. It is also implemented in the smart cane, which will detect if any obstacle is ahead on the way. So the user can be alerted with the voice message.
4. Inertial sensor: In order to keep the user in proper direction, we are collecting the accelerometer and compass data from the smart phone attached to the user's body. As per this data we can guide the blind user about the angle and speed of his motion while navigating to his destination.
5. Speech-To-Text(STT) module : The blind user can input his desired location as a voice message in the developed STT module. This voice message is converted to text and delivered to the server.
6. Direction Guider : After receiving the input destination, the direction guider will send the recommended path to the TTS(Text-To-Speech) module.
7. Text-To-Speech(TTS) module : The desired route can be played as voice message to the user. We are using the Google voice API, which is a free online service by Google[6].

8. Headphone : The blind person can listen the voice message through the headphone and follow the directions. This acts as an actuator for the system.

IV. Technical Implementation

The implemented system structure is shown in figure 4. As shown in the figure the blind user's cane contains the RFID reader and ultrasonic sensor. These two sensors are connected to the Arduino. Arduino [7] consists of a programming environment and Arduino boards. This programming environment facilitates the developer to manage, compile, upload and simulate programs. Then the Arduino board is connected to the raspberry pi, which connects to the server through Internet. The RFID tag and ultrasonic data is sent to the server through the Internet.

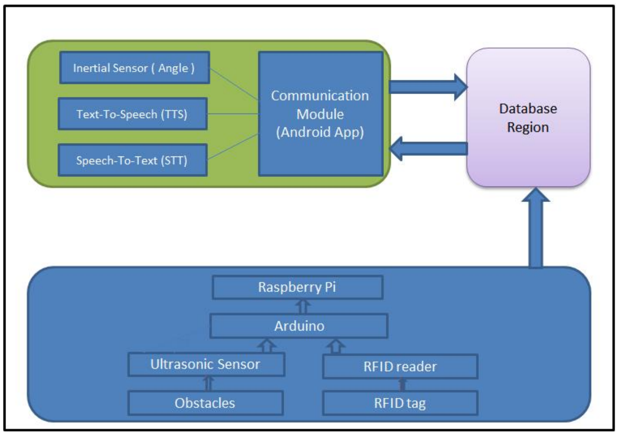

표 4. 시각장애인 용 IoT 내비게이션 시스템 구성도
Fig. 4. IoT navigation system structure for a visually impaired person

We have implemented the MPEG-V standard data format for the ultrasonic sensor which measures the distance of the object ahead. The syntax and semantics for the "distance sensor type" is based on the XML schema as shown in figure 5.

A corresponding example of the XML instance of the sensed information generated by the raspberry pi is shown in figure 6. This XML instance indicates the sensor is activated and the distance measured is 5 meter.

The communication module is the developed android application as shown in figure 7. This application consists of a step counter, angle. The inertial sensor in the smart phone identifies the current direction of the user. So in our use case smart phone plays an important role in helping the

```
<!--#################################### -->
<!--Definition of distance sensor type   -->
<!--#################################### -->
<complexType name="DistanceSensorType">
   <complexContent>
      <extension base="iidl:SensedInfoBaseType">
         <attribute name="value" type="float" use="optional"/>
         <attribute name="unit" type="mpegvct:unitType" use="optional"/>
      </extension>
   </complexContent>
</complexType>
```

그림 5. 거리 센서 데이터의 MPEG-V 스키마 신택스
Fig. 5. MPEG-V schema syntax for a distance sensor

```
<iidl:InteractionInfo>
   <iidl:SensedInfoList>
      <iidl:SensedInfo xsi:type="siv:DistanceSensorType" id="DS001"
         sensorIdRef="DSID001" activate="true" value="5.0" >
         <iidl:TimeStamp xsi:type="mpegvct:ClockTickTimeType" timeScale="100"
            pts="60000"/>
      </iidl:SensedInfo>
   </iidl:SensedInfoList>
</iidl:InteractionInfo>
```

그림 6. 초음파 센서 데이터의 MPEG-V XML 인스턴스
Fig. 6. MPEG-V XML instance of ultrasonic sensor data

blind person to navigate on his way. We designed the smart cane which contains the RFID reader, and the ultrasonic sensor connected to arduino and raspberry pi as shown in the figure 8.

그림 7. 안드로이드 앱
Fig. 7. Android application

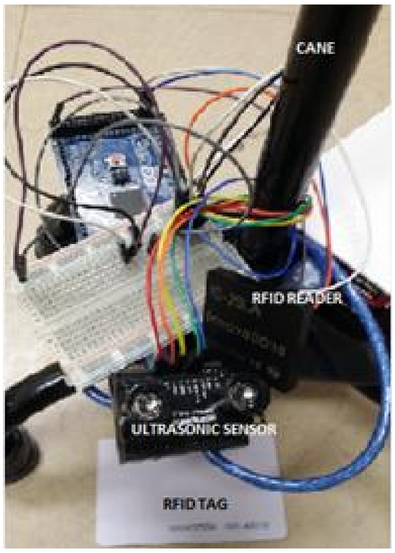

그림 8. 제작된 지팡이 모습
Fig. 8. The implemented cane

V. Experiment And Results

We set up a small route in the campus installing seven RFID tags on the way as shown in figure 9. Suppose the Blind user is currently in location “A” and he sends the destination location as “D”. The server can find the route to guide the user with the information described in the table 1. The mobile speaker tells the blind user to go straight until he reaches RFID tag-2. After that user is instructed to walk in an angle of 270 degree until RFID tag-3 and so on. The green line shows the route received from the server from source location “A” to destination “D”.

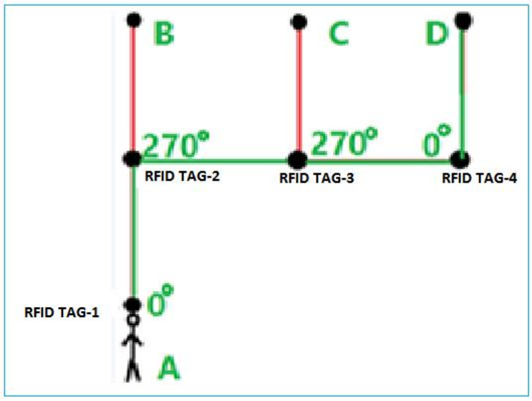

그림 9. RFID 태그 및 태그 간 각도 정보 경로도
Fig. 9. Route description with RFID tags and direction angles

표 1. 경로 정보 테이블
Table 1. Information of the route table in the server

Start position	End destination	RFID 1 & angle	RFID2 & angle	RFID 3 & angle	RFID 3 & angle
A	D	1 & 0	2 & 270	3 & 270	4 & 0
A	B	*****	*****	*****	*****

The system is tested in the campus itself. We installed the RFID tags on the floor. Five normal subjects blind folded by an eye mask took the test. The results of the system are satisfactory. All the subjects were able to reach at the destination as per the mobile voice message. However, there is a certain delay of time in receiving the voice message from the server.

VI. Conclusion & Future Work

In this paper, we proposed an IoT navigation system for visually challenged people. This kind of system can help the blind people to lead an independent life. The system shows good result in detecting the blind’s location and helping him to navigate to his desired destination. Along with this, the user is also continuously aware of any obstacles on the way.

Our future research will involve more features like landmark detection while the blind user navigates on his ways and some more actuators like vibration globes other than the voice message to alert the user. We believe that this vision disabled-aid at the context of IoT can help the visually impaired to a certain extent.

참 고 문 헌 (References)

[1] V. Prudtipongpun, W. Buakeaw, T. Rattanapongsen and M. Sivaraksa, "Indoor Navigation System for Vision-Impaired Individual: An Application on Android Devices," Bangkok, 2015, pp.633-638.
[2] R. Sammouda and A. Alrjoub, "Mobile blind navigation system using RFID," Sousse, 2015, pp.1-4.
[3] S. Chumkamon, P. Tuvaphanthaphiphat and P. Keeratiwintakorn, "A blind navigation system using RFID for indoor environments," Krabi, 2008, pp.765-768.
[4] Kim, Cheol-Min; Kang, Hyung-Woo; Choi, Sang-Il; Koh, Seok-Joo, "Implementation of CoAP/6LoWPAN over BLE Networks for IoT Services," Journal of Broadcast Engineering, vol. 21, issue 3, pp 298-306, 2016.
[5] Lahiri, S. (2006). RFID Sourcebook IBM Press. Mahson, S. and M. Ilyas (2008). RFID Handbook: Applications, Technology, Security and Privacy, CRC Press, Taylor & Francis Group.
[6] Google Developers, (2015). Overview of the Voice Interaction API. [online] Available at: https://developers.google.com/voice-actions/interaction [Accessed 17 Sep. 2015]
[7] Arduino, “http://www.arduino.cc/”
[8] ISO/IEC 23005-5 Information technology－Media context and control－Part 5: Data Format for Interaction Devices, August 2010, ISO Publication.
[9] S.-K. Kim, S.J. Han, J.J. Han, Y.S. Joo, M.H. Shin, “Virtual world control system using sensed information and adaptation engine,” SIGNAL PROCESSING-IMAGE COMMUNICATION, vol. 23, pp. 87-96, 2013

저 자 소 개

Nevadita Sahu

- 2002년 ~ 2006년 : Bachelor’s Engineering(B.E) in computer Science & Technology, BPUT, India
- 2006년 ~ 2010년 : Embeded Software Engineer, Wipro Technology, Bangalore, India
- 2015년 ~ 2017년 : Master’s in computer engineering, Myongji University, South Korea
- Interest : Internet of Things, Big data analysis, Database Applications

정 민 혁

- 2009년 ~ 2016년 : 명지대학교 컴퓨터공학과 학사
- 2016년 ~ 현재 : 명지대학교 일반대학원 컴퓨터공학과 석사과정
- 주관심분야 : Internet of Things, 4D media, sensors and actuators, VR

저 자 소 개

전 종 훈

- 1992년 : 노스웨스턴대학 (Northwestern University) 컴퓨터공학 MS(1988), PhD
- 1986년 : 덴버대학 (U of Denver) 전산과학 BS
- 1992년 9월 ~ 1995년 6월 : 센트럴 오클라호마 주립대학 (U of Central Oklahoma) 전산과학과 조교수
- 1995년 9월 ~ 2016년 3월 : 명지대학교 컴퓨터공학과 교수
- 2016년 3월 ~ 현재 : 명지대학교 융합소프트웨어학부 교수
- 2011년 4월 ~ 현재 : ㈜프람트테크놀로지 대표이사 기술연구소 소장
- 주관심분야 : Dababase, Big Data, Smart Signage, Data Mining and Recommender Systems, Information Retrieval, eBusiness Solutions, Medical Informatics, and Supplier Relationship Management

김 상 균

- 1997년 : 아이오와 대학 (U of Iowa) 전산과학 BS(1991), MS((1995), PhD
- 1997년 3월 ~ 2007년 2월 : 삼성종합기술원 멀티미디어랩
- 2007년 3월 ~ 현재 : 명지대학교 공과대학 컴퓨터공학과 교수
- 2016년 3월 ~ 현재 : 명지대학교 IT융합대학 융합소프트웨어학부 교수
- MPEG 국제표준화 (MPEG-7, MPEG-A, MPEG-V, IoMT & W) 내 다수의 의장/에디터 수임
- ORCID : http://orcid.org/0000-0002-2359-8709
- 주관심분야 : digital content (image, video, and music) analysis and management, fast image search and indexing, color adaptation, 4D media, sensors and actuators, VR, Internet of Things, and multimedia standardization